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Marine Casualty Investigations

Enquêtes sur les accidents maritimes

Investigation Report to the Minister pursuant to sections 542 or 545 of the Canada Shipping Act

Rapport d'investigation au Ministre conformément aux articles 542 ou 545 de la Loi sur la marine marchande du Canada

Canada

Ce rapport est aussi disponible en français.

REPORT OF INVESTIGATION INTO THE CIRCUMSTANCES ATTENDING THE DEATH OF A CREW MEMBER ON BOARD THE LIBERIAN CHEMICAL TANKER "CHIPPEWA" AT SARNIA, ONTARIO DECEMBER 16, 1986.

REPORT No. 484

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REPORT OF INVESTIGATION INTO THE CIRCUMSTANCES ATTENDING THE DEATH OF A CREW MEMBER ON BOARD THE LIBERIAN CHEMICAL TANKER "CHIPPEWA" AT SARNIA, ONTARIO DECEMBER 16, 1986.

Particulars of Vessel

Name	"CHIPPEWA"
Official Number	6955
Port of Registry	Monrovia
Flag	Liberian
Call Sign	ELAT 7
Gross Tonnage	11,781
Registered Tonnage	7,342
Length Overall	154.01 m
Breadth Extreme	22.74 m
Depth Moulded	13.82 m
Draught	F: 7.00 m A: 7.00 m
Type	Petro-Chemical Tanker
Built	1981, Shimonoseki, Japan
Propulsion	Diesel, 16,080 BHP
Cargo	5,300 m/tons toluene 4,300 m/tons xylene
Crew	23
Classification Society	American Bureau of Shipping
Certification	Cargo Ship Safety Equipment certificate issued at Sarnia, Ontario, October 19, 1986 and valid until April 9, 1987. Cargo Ship Safety Construction certificate issued at Paramus, New Jersey, June 26, 1986 and valid until December 30, 1986. ABS Loadline certificate issued at

New York, June 19, 1986 and valid until April 8, 1991.

Last Freeboard survey conducted at Rotterdam, April 8, 1986.

ABS Certificate of Fitness for the carriage of dangerous chemicals in bulk issued at Paramus, New Jersey, August 22, 1986 and valid until April 8, 1991.

Owner — Hope Crown Shipping Company
Monrovia, Liberia.

Operators — Sun Transport
Aston, Pennsylvania, USA.

Description of the vessel

The "CHIPPEWA" is a petro-chemical carrier with six cargo tanks divided by two fore and aft bulkheads. To satisfy the construction requirements - the IMO Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (BCH Code) for a Type II Ship, the following modifications to the usual arrangement of tanks were made in order to carry dangerous chemicals in bulk:

- No. 2 tank: port and starboard side tanks continued below the centre tank to a centreline bulkhead so that No. 2 centre tank is protected by a 'double bottom';
- No. 5 tank: has a double bottom tank which is used for 'cleaning fresh water' below the centre tank only, the two side tanks are used for water ballast;
- No. 6 tank: has been divided by an athwartship bulkhead in the centre tank to create two slop tanks at the after end; and
- the cofferdam between No. 6 tank and the engine-room has been continued forward under the slop tanks to give them double bottom protection.

Background

NOTE 1) All times in this report are Eastern Standard Time (UTC minus 5 hours).

2) A glossary of abbreviations and terms can be found following the Findings in this report.

The "CHIPPEWA" and her sister ship the "NORDIC SUN" have been employed for several seasons in the transportation of chemicals between the Great Lakes and Europe, and the Italian crews are interchanged to suit vacation and service requirements. The "CHIPPEWA" had shipped a cargo of liquid urea ammonium nitrate from Rostock, East Germany and discharged in Toledo, Ohio and Bay City, Michigan.

After leaving Bay City, December 12, No. 3 starboard tank was washed with a mixture of water from the slop tank and a quantity of toluene, after which it was ventilated. An inspection following the vessels arrival in Sarnia, December 12, showed 'spots' of the previous cargo, so the tank was again washed with water and toluene and then ventilated.

On December 14, loading of a cargo of toluene commenced at 1130 into No. 2 centre and No. 6 across tanks. Loading of the toluene cargo was completed at 0725, December 15. At 1300, December 15, loading of xylene was commenced into tanks No. 1 across (port, centre and starboard) and No. 4 across. The vessel was bound for Rotterdam via Marcus Hook, Pennsylvania; toluene would be loaded into No. 3 tanks across at Marcus Hook.

At 0510, December 16, following a test on the atmosphere in No. 3 starboard tank, a seaman wearing a face mask only (but probably not over his mouth) entered the tank to set up an air driven pump to remove wash water. The shadows from his flashlight were observed to stop moving by the bosun on deck and when he failed to respond to a call, the rescue team was assembled and his unconscious body was brought to the deck where mouth to mouth resuscitation was given. An ambulance transported the seaman to Sarnia General Hospital where he arrived at 0614 and was pronounced dead at 0626.

Particulars of Deceased

Name	Vincenzo Terlizzi
Position on vessel	Seaman
Age	45
Address	Genoa, Italy

Narrative

After shipping a cargo of toluene from Sarnia to Rotterdam

in November 1986, the "CHIPPEWA" loaded a cargo of urea ammonium nitrate at Rostok, East Germany, November 23rd, and sailed for the Great Lakes. Discharge from No. 3 port, centre and starboard tanks was completed at Toledo, Ohio by 1140, December 9th.

The "CHIPPEWA" sailed for Bay City, Michigan where the balance of her cargo was discharged. She left Bay City at 0930, December 12th. On the same day, from 1030 to 1300 while under way for Sarnia, No. 3 starboard tank was washed out with water, and a small amount of toluene and naptha (residues from previous cargoes) and then ventilated. Arriving at Sarnia at 2030 the same day, the vessel secured starboard side to Sun Oil Company wharf.

Following her arrival, the tank was examined, and spots of the rust inhibitor in the previous cargo were observed, so it was washed again December 13 for three thirty-minute periods using water from the slop tank, and toluene which had been taken on board for this purpose. The ventilation fan blew fresh air into No. 3 tanks from 1000, December 15 until 0630, December 16.

The boatswain and Terlizzi went on duty at 0400 and the boatswain asked the second officer to check No. 3 tanks. At 0415 the second officer accompanied by the two men, checked No. 3 starboard, centre and port tanks with the combustible gas detector and obtained a zero reading. The second officer said he had doubts about No. 3 starboard due to a loose grub screw on the control switch of the detector. The boatswain put his face to the air stream issuing from the tank and pronounced the tank clean.

They returned to the control room where the chief officer was on duty. The second officer reported to the chief officer that they had tested No. 3 tanks across and obtained zero readings on the combustible gas detector. He also pointed out the faulty switch and the chief officer indicated that this would not affect the meter reading. The second officer then retired.

After discussing the tank cleaning with the chief officer, the boatswain and Terlizzi went back on deck and the boatswain, not wearing a breathing apparatus but with a face mask worn around his neck, descended to the bottom of each of the three tanks and inspected them. He observed water in the centre and starboard tanks, with a tonne or two of water in No. 3 starboard tank. During this inspection, he was watched by Terlizzi who stood at the tank entrance hatch. Returning to the deck, the boatswain reported to the chief officer in the control room, that No. 3 starboard and centre tanks needed water removing from them.

At 0510, the boatswain and Terlizzi lowered a portable air driven pump to the bottom of No. 3 starboard tank by rope. When

the boatswain started to descend, Terlizzi insisted that he do his fair share of the work and that it was now his turn to go down. Wearing a face mask around his neck and taking a portable electric light for illumination, he descended the ladders to the bottom of the tank. Making his way through the opening in the after web frame, he placed the lamp on the flange of one of the frames and went to attend to the pump suction hose. The boatswain remained on deck to watch at the entrance hatch and observed Terlizzi's movements in the tank. After two to four minutes, he observed that the shadows had stopped moving and he called to Terlizzi, but his call went unanswered.

The boatswain ran to the control room and told the chief officer, and then went to the crew's quarters and alerted other members of the crew before returning to the tank hatch.

The chief officer ran to No. 3 starboard tank and donned a self-contained breathing apparatus which was ready nearby. He descended the tank ladders and found Terlizzi in the after section lying on his side in the fifth frame space from the centre tank bulkhead, with his face partially in the liquid in the bottom of the tank.

Unable to put the safety belt properly around the seaman's shoulders due to his heavy weight, the chief officer put the belt around his waist and had the rescuers on deck haul Terlizzi up. They were only able to raise the unconscious man about 1.5 m above the bottom of the tank before it became apparent that more help was required to raise the heavy man. Also, the chief officer's breathing apparatus sounded a low air supply alarm; in addition he had problems with his legs freezing due to scant clothing. He returned to the deck and alerted the master and called for an ambulance, while the boatswain and the other men rigged a line to the winch. Wearing another breathing apparatus, the boatswain went into the tank as the unconscious man had to be manoeuvred past the ladder platform.

When he was placed on deck, the master gave mouth to mouth resuscitation which proved to be difficult due to the liquid in the seaman's mouth. He was placed in an ambulance and taken to Sarnia General Hospital arriving there at 0614 and was pronounced dead at 0626.

Analysis

1. Cause of Death

Acute toluene intoxication was given as the cause of death in the post mortem report.

The Toronto Centre of Forensic Sciences report indicated that 0.3 mg% of toluene was detected in a blood sample taken from the deceased. This reading is within the toxic range. There was no evidence of cargo wash water in the lungs.

2. **Urea Ammonium Nitrate**

Urea ammonium nitrate is a fertilizer and is carried in the tanks in solution with water. It has no synergistic effect on people when mixed with toluene. Due to its highly corrosive effects on steel tanks, it was found expedient to introduce a rust inhibitor. After discharge of a cargo, deposits of this rust inhibitor are found adhering to the painted tank surfaces and must be removed to prevent contamination of other cargoes which may be carried. Several methods of removing this rust inhibitor residue have been tried but the only effective remedy so far discovered is to wash the tank with water and toluene.

3. **Toluene**

Toluene is a clear, colourless liquid with an aromatic odour and is produced by several petroleum and petrochemical processes. It is an excellent solvent for many oils, fats, waxes, paints, lacquers and rubber.

The primary hazard is flammability, its flash-point is 4°C (40°F), and concentrations with as little as 1.2% toluene by volume in air are flammable.

Short term over-exposure to toluene may cause irritation of the eyes, skin and respiratory tract. Inhalation of toluene vapours produces narcotic effects such as feelings of fatigue, muscular weakness, drowsiness, confusion and headaches.

Cases of severe over-exposure have caused severe but reversible liver and kidney damage. Liquid toluene splashed in the eyes can result in irritation and temporary reversible damage.

Long term exposure to toluene causes the skin to dry and crack because of its solvent action which breaks down the body's oils. If toluene enters the lungs it can cause chemical pneumonia.

Toluene was originally specified as a Class C noxious substance under Annex II of the IMO Marpol Convention but following a meeting of the International Marine Safety Committee, circular No. 452 was issued July 1, 1986 upgrading Toluene to a Class B substance. Consequently,

shipment was permitted in chemical tankers only.

Properties

Appearance	Colourless liquid
Specific gravity	0.87 (20°C) - floats on water
Vapour pressure	10 mm Hg (6.4°C)
Odour threshold concentration	Aromatic, 0.17 to 40 ppm in air
Flash point	2.8°C (open cup); 4°C (close cup)
Vapour density	3.1 (air = 1)
Explosive limits	1.2 to 7.1%
Threshold limit value	100 p.p.m., (375 mg/m3)
Short-term inhalation limits	150 p.p.m., (560 mg/m3)
Immediate Danger To Life and Health	2000 p.p.m., (7,500 mg/m3)

4. **Particulars of No. 3 starboard tank**

No. 3 starboard cargo tank has a capacity of 2568.18 cubic metres, and is not fitted with a double bottom, meaning that the bottom of the tank is the bottom of the ship. The inner surface is painted with a light coloured epoxy giving a smooth surface.

frame numbers	60 to 65
length	16.50 m
breadth	5.68 m
depth	13.80 m
deep well cargo oil pump	port side aft
oil-tight hatch	after end
fixed tank cleaning machines	two with two butterfly valves in line

ventilation inlet pipes	one forward (through main deck) one aft (through oil tight hatch coaming).
purge pipe	one: 15.24 cm (6 in) i.d. extending from 49.53 cm (19.5 in) above bottom of tank through deck, total length 14.99 m. It is located 1.83 m (6 ft) from the centre tank bulkhead and 30.48 cm (1 ft) from the after bulkhead.

The framing is longitudinal with four transverse web frames spaced on 3.3 m centres and the boundary bulkheads fore and aft have horizontal corrugations. The longitudinal frames at the position where the man died are spaced 78.74 cm (31 in) apart and consist of angle bars 44.45 cm (17.5 in) high with a 15.24 cm (6 in) flange at the top, pointing inboard. The access to the bottom of the tank is by four flights of stairs which pass from the oil-tight hatch through the after web frame and land in the second bay from aft. Access through the web frames is via a manhole 60.3 cm (23.75 in) by 80 cm (31.5 in) with a sill 54.6 cm (21.5 in) high at the fourth frame space from the inboard bulkhead. It was indicated that the body was found in the fifth frame space from the inboard bulkhead.

There are three drain holes at the bottom of the fourth frame measuring 14.6 cm (5.75 in) by 7 cm (2.75 in), spaced about 130 cm (51.2 in) apart. Their total cross-sectional area is about 247 cm^2 (42.5 in^2).

As the vessel was said to be trimmed by the stern with a list to starboard, these holes could have been immersed in water which was reported to be about 15 cm deep, preventing air circulation and allowing a pocket of toluene vapour to evolve with concentration strength and depth in sufficient quantity to incapacitate a person when inhaled.

5. Pumping Arrangements

On the "CHIPPEWA", each tank has its own hydraulically-driven deep well cargo pump. In addition to discharging cargo, this pump is used for removing wash water to the slop tanks. The wash water is pumped into the tanks through two fixed tank washing machines (located below the main deck) which direct jets of the liquid to all the tank surfaces. The cargo pump suction in No. 3 starboard tank is located about 15 cm (6 in) above the bottom and any liquid below

that level is removed by means of a portable air driven pump (fixed stripping pumps were installed in the spring of 1987 to comply with MARPOL 73/78 Annex II - See Annex V).

6. **History of tank**

Tank Washing: In order to prepare the cargo tanks for the next cargoes of toluene and xylene, they had to be washed clean. The air temperature in Bay City was -8°C, December 10, and the wash lines had to be prevented from freezing.

Washing was started at 0900, December 12, using water heated to a temperature of between 30°C and 40°C and the fixed and portable tank washing machines were used as required.

No. 3 starboard tank was washed with water from 1130 to 1300, December 12, using water and slops containing residues of toluene and naptha. At 0700, December 13, about 4 m3 of toluene was loaded into the slop tanks for tank cleaning purposes.

Tank washing was resumed at 0923 with No. 3 starboard being rinsed with toluene and water from 1021 to 1050, and from 1130 to 1200, then again from 1400 to 1430.

7. **Water Heating**

December 12, from about 0900 until 1730, the wash water was heated to a temperature of 35°C on the heater.

On December 13, from 0920 until 1230, the water was not heated and had a temperature of about +4°C.

On December 13, from 1230 until 1630, the water was heated to a temperature of 20°C on the heater. At the time of the incident, the approximate temperature of the water left in No.3 starboard tank was about +2°C.

Sea water temperature was about +5°C.

8. **Ventilation of No 3 tanks**

The fan was operating from 1000, December 15 to 0630, December 16; the capacity of the fan was 3000 cubic meters per hour, (to all No.3 tanks across). No. 3 starboard tank hatch was opened at 0430, December 16.

9. **Vapour Detection**

The vapour detection instruments on the "CHIPPEWA" are those specified by the IMO - Code for the Construction and

Equipment of Ships Carrying Dangerous Chemicals in Bulk, Section:

D. VAPOUR DETECTION

3.11 General

3.11.1 Ships carrying toxic and/or flammable cargoes should be equipped with at least two instruments designed and calibrated for testing for the specific vapours in question. If such instruments are not capable of testing for both toxic concentrations and flammable concentrations, then two separate sets of instruments should be provided.

3.11.2 Vapour detection instruments may be portable or fixed. If a fixed system is installed, at least one portable instrument should be provided.

The "CHIPPEWA" was provided with two portable combustible gas detectors and the following for testing tank atmospheres:

two oxygen analyzers

two Drager pump type toxic meters with a supply of dated chemical tubes for testing the atmospheres of the various cargoes carried. The number of parts per million of a toxic gas can be detected with this instrument.

One Fyrite indicator for testing the atmospheres of tanks which have been inerted. This instrument is capable of giving the percentage of oxygen and carbon dioxide in a sample.

10. <u>The Combustible Gas Detector (Explosiometer)</u>

This is a hand held portable instrument which measures the percentage by volume of the lower flammable limit of hydrocarbon gas present in an enclosed space.

When a mixture of combustible gas and air is drawn through the instrument by a built-in pump, a needle on the scale indicates the percentage by volume of the lower flammable limit of the hydrocarbon gas in the atmosphere being tested.

It was indicated that the atmosphere of No. 3 starboard tank was tested by holding the instrument suction tube inside the

purge pipe in the stream of air being forced from the tank by the ventilation fan. Under these circumstances, it does not seem likely that a different reading would have been obtained by lowering the suction tube extension to the bottom of this pipe.

After the victim was removed, the Sarnia Police had the combustible gas detector demonstrated to them on board and a reading of 6% of the lower flammable limit was obtained when the extension tube was lowered down the purge pipe. This reading was taken over two hours after the ventilation fan had been stopped. The police took possession of the instrument and sent it to the Toronto Centre of Forensic Sciences for examination. The results of the examination do not prove conclusively that the instrument was not working properly at the time the second officer tested the atmosphere of No. 3 starboard tank. The velocity of the air up the purge pipe was about 6 m/s. The effect of the velocity of the air in the purge pipe, at the time of testing, is not known.

11. Sample of liquid from No. 3 Starboard Tank

Following a request on December 16, a one litre sample of the liquid in the bottom of No. 3 starboard tank was obtained. This liquid was analyzed and was found to consist of toluene and fresh water but the method of sampling did not provide for an accurate analysis of their proportions.

12. Gas Freeing and Tank Cleaning

The Tanker Safety Guide (Chemicals) Volume 1, 1974 published by the International Chamber of Shipping states:-

> 5.6 TESTING OF SPACES FOR VAPOUR
>
> Gas-freeing equipment should be operated as long as is necessary to ensure that the cargo tank or other space is sufficiently free of flammable and harmful vapours for the particular purpose.

The tank was ventilated using the inert gas system blower for a prolonged period (18 hours) before the test was made.

> Appropriate gas indicators should always be used for testing the atmosphere in the space (see Chapter 6).
>
> Adequate samples should be taken from separated points about the space to ensure

that it is free of vapour throughout. It is important to remember that, depending on its density, vapour may accumulate preferentially at the top or bottom of the space and also in locations where the flow of ventilating air is least.

The flow of air up the purge pipe was considered to be a representative sample of the tank atmosphere and the combustible gas indicator was held in this flow for longer than required for a single sample to be taken.

CHAPTER 6

WORK IN ENCLOSED SPACES

6.1 GENERAL

When work in enclosed spaces is intended all measures should be taken, bearing in mind the nature of the hazards given in the data sheets, to create safe working conditions for personnel. The most stringent precautions should be taken even if the duration of the work involving personal exposure is to be short.

6.2 EFFECTS OF VAPOURS ON PERSONNEL

The concentrations of cargo vapour that personnel can withstand depends on many factors, for example the nature of the particular vapour, the duration of the exposure, the frequency of the exposure and the state of health and vapour tolerance of the personnel. Because of these many factors, the Master should make it a general rule that there should be no entry into tanks except in special circumstances, (see 6.4.3) unless the tanks have been tested, with appropriate equipment (see 6.4) by a responsible officer and found free of toxic concentrations of vapour (i.e. dangerous concentrations should be below the TLV-see 9.4.3) and not deficient in oxygen (see 6.3).

The same precautions should be taken before entry into other spaces, e.g. cofferdams, double bottoms and pumprooms into which cargo liquid or vapour may have leaked.

6.3 OXYGEN DEFICIENCY

Oxygen deficiency should be suspected in any compartment which:-

(a) has been closed for any length of time,
(b) has been inerted,
(c) has contained a volatile cargo (even though the cargo vapour is not harmful).

Such compartments should not be entered until thorough ventilation has restored the oxygen to normal atmospheric level (21%).

No tests of the oxygen content of the air were made. However, due to the prolonged ventilation it was probably not deficient in the atmosphere ascending the purge pipe and any such test may have been misleading.

6.4 ENTRY INTO COMPARTMENTS

6.4.1 General

No one should enter a cargo tank, cofferdam, double bottom or similar enclosed spaces without permission from a responsible officer who is satisfied that the atmosphere therein is safe in all respects for entry.

The tank atmosphere was tested with a combustible gas detector and the second officer suspected that the reading may be faulty due to a loose screw on the instrument knob. The performance of the explosiometer may have been affected by the velocity of the air as it issued from the purge pipe. The boatswain tested the tank atmosphere by breathing and smelling the air as it issued from the purge pipe and pronounced the tank clean. The boatswain, not wearing a breathing apparatus, descended to the bottom of the tank to inspect its condition and did not encounter a heavy concentration of toluene vapour. He had conducted this test in a similar manner on these ships for some six years and had found the practice to be safe.

The responsible officer should ensure that:-

(a) a competent person is standing-by at the entrance to the space to call assistance if necessary,

The boatswain stationed himself at the tank entrance hatch and gave the alarm when Terlizzi did not respond to his call.

(b) the space is continually and effectively ventilated,

The fan had been supplying fresh air to the tank for 18 hours prior to the test.

(c) lifelines and harness are ready for immediate use,

Available but not particularly suitable hoisting arrangements were rigged.

(d) approved breathing apparatus is ready for immediate use,

The self-contained breathing apparatus was on the grating near to the hatch lid.

(e) suitable notices are prominently displayed forbidding unauthorised entry,

(f) persons in the compartment wear goggles and protective clothing as recommended in 9.3.2 to guard against contact with harmful cargo.

The victim was wearing protective clothing and had an interchangeable respirator around his neck ready for use, when he entered the tank. This respirator consists basically of a mask with filter cartridges attached; the filters are mainly activated charcoal which has great affinity for hydrocarbon vapours, the toxic air being drawn through the filters by the aspirational effort of the wearer. This respirator is used for protection against respiratory hazards of light concentrations of organic vapours. The chief officer enforced a rule that everyone entering a tank should have the respirator around his neck and available.

A self-contained breathing apparatus was ready for use outside the tank. The objections to the routine use of a self-contained breathing apparatus whenever tank entry is made in 'gas free' atmospheres are:

1. Mass: A breathing apparatus with a full air tank for 30 minutes weighs about 13.6 kg (30 lb) and most tankers have steep ladders.

2. Visibility: The face mask severely restricts visibility.

6.6 GAS INDICATORS-TESTING BEFORE ENTRY INTO ENCLOSED SPACES

6.6.1 General Responsibilities

It is the duty of the responsible officer to verify that the atmosphere in a cargo tank, cofferdam, double bottom or similar enclosed space is safe in all respects for entry and for the work to be done in the space. The primary means of testing the atmosphere in the space is a properly tested and efficiently working gas indicator.

Frequent tests should be made with a gas indicator to ensure that the atmosphere is safe throughout the period that personnel are in the space and work is in progress. The responsible officer should not be satisfied with a gas indicator reading on a sample taken from only one point in the space since there may be pockets and layers of vapour elsewhere.

The "CHIPPEWA" is fitted with only one purge pipe for each tank. This appears to be the usual practice in tanker construction, the idea being to limit the number of openings through which gases and liquids can escape and the purge pipe doubles as an ullage opening when required. The Code for Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk, requires inter alia:

C. GAUGING

3.9 General

Cargo tanks should be fitted with one of the following types of gauging devices:

(a) **Open device** which makes use of an opening in the tank and may expose the gauger to the cargo or its vapour. An example of this is the ullage opening.

As the "CHIPPEWA" has its engines and accommodation aft, it could reasonably be expected that toluene vapour being heavier than air would drain by gravity to the after end of the tank where it would be entrained in the air being forced up the purge pipe. However, this did not appear to occur on this occasion and we have to examine possible explanations.

With the vessel on an even keel or with a list to port, the drain holes at the bottom of the longitudinal frames in the

area where the man died would not have been immersed in water and proper air circulation would have been obtained. The three drain holes have a total cross-sectional area of approximately 247 cm^2.

As the vessel was not equipped with permanently installed stripping pumps it necessitated portable pumps being placed, and this was the work being undertaken by Terlizzi when he died. However, such pumps were installed after the accident, not because of the accident but to comply with MARPOL 73/78 Annex II. Such stripping pumps should remove the final amounts of wash water without resorting to portable pumps.

The disadvantage of having only one point at which to test the atmosphere might be overcome by stopping the ventilation fan, allowing the air currents to change, then testing in the purge pipe using an extended hose on the combustible gas indicator, with only the natural air flow through the pipe and a further test after the ventilation fan has been started again. A list to port would help at No. 3 starboard tank.

13. **Deep Vortex Fans**

In addition to the inert gas system blower fans, the "CHIPPEWA" is equipped with portable, water-driven deep vortex fans which can be mounted in a hole in the main deck and are capable of agitating the atmosphere down to the bottom of the tank and between the frames. The disadvantage of being water-driven is that they cannot be operated when water is at the freezing temperature and they were not used on this occasion.

14. **Time**

There does not appear to have been any requirement for undue haste to complete the tank cleaning. No. 3 across tanks were gas freed for a safe passage through the Seaway and would not be loaded until the vessel reached Marcus Hook, Pa., on the Delaware river, a time interval of several days. Advantage was taken of the lull provided while cargo was being loaded to perform this necessary, though not immediate, task.

15. **Theory on Causes of Accident**

Tanks which have contained hydrocarbon liquids are ventilated in order to remove the liquid by evaporation. With experience it was known that after a number of hours with the ventilation fan in operation, the toluene residues would probably all have evaporated, and with this in mind

the boatswain approached the second officer to have the No. 3 cargo tanks tested for entry.

A zero reading on the explosiometer (combustible gas detector) at the purge pipe was taken to mean that the toluene had evaporated, and that it was safe for the boatswain to descend to the bottom of the No.3 tanks across. With the death of Vincenzo Terlizzi, it was necessary to consider how a pocket of toluene vapour could have formed and remained in the vicinity of the fifth frame space from the inboard bulkhead, and the variables from the conditions which had made the testing with a combustible gas detector at the purge pipe successful on previous voyages but inadequate on this occasion.

Temperatures: The river water temperature was just above freezing while the air temperature reported at midnight was 6°C. The air used to ventilate No. 3 was probably warmer having been drawn from the upper part of a warm engine room and passed through the heated inert gas system deck water seal. The net results may have been warm air in the tank over a cooler liquid at the bottom of the tank.

Vessel trimmed by stern: It was reported that the fore end of the tank was dry while the after end had about 15 cm of wash water.

List to starboard reported: The wash water collected towards the starboard side of the tank and thereby covered the drain holes in the frames. With a steady flow of warm air, the toluene floating on the water in the inboard frame spaces all evaporated. A pattern of air currents developed so that the warm air flowed aft along the longitudinal frames and to the purge pipe. The water in the fifth frame space of the after bay covered the drain holes in the bottom of the longitudinal frames so that the ventilation between it and the next frame space inboard was cut off.

Vapour evolved from the toluene in the fifth frame space was trapped by its density (3 times as heavy as air) and temperature and the air currents in a similar manner to snow in a snow drift.

Fresh air circulated through the tank and up the purge pipe gave a zero reading on the combustible gas detector.

When the boatswain inspected the tank, he had no need to enter the after bay or the fifth frame space. He could make a proper assessment of the amount of wash water through the opening in the after web frame. In addition, he was a good head taller than Terlizzi and probably remained erect while

in the tank.

When Mr Terlizzi went to the fifth frame space, he probably bent down to grasp the pump suction pipe and suddenly encountered the pocket of toluene vapour and drew enough of it into his lungs to paralyse and incapacitate him.

It was argued that Terlizzi, an experienced tankerman, would have smelled the toluene vapour and his eyes would have watered and he would have retreated to the ladder and fresh air.

This is a valid argument for a space which is not being ventilated, but the conditions inside No. 3 starboard tank at that time may have been such that there was a sharp demarcation between the fresh air being blown in and the pocket of toluene vapour.

In addition, the opening of the oil tight hatch could have altered the pattern of air currents from the time the test of the atmosphere was made at the purge pipe and Terlizzi's entrance to the after bay.

16. **Tank Surveys**

Prior to loading the cargo tanks in Sarnia, they are inspected by an independent company specializing in this type of survey. It is their practice, when entering a tank which has contained toluene and presented by the vessel as being gas free for entry, to first make their own independent test of the tank atmospheres.

Using their own instrument which is a combined combustible gas detector and oxygen analyzer, the cargo tank surveyors lower the suction hose through the hatch opening and test the atmosphere at all levels from top to bottom for hydrocarbon gas and oxygen content before entering the tank. If the ventilation is running at the time of the test, they insist on it continuing to run while they are inside the tank.

As No. 3 tanks across were not to be loaded in Sarnia, this test by independent surveyors was not made.

It is probable that on December 16, that using this additional test may not have revealed the pocket of high concentration toluene vapour if the suction tube had descended into a frame space which had been swept clean by the ventilation fan.

Canadian requirements for tank testing and entry are contained in the:-

17. **Safe Working Practices Regulations** Sections 2,3,4,5,6 and 30 (see Annex III).

18. **Company Standing Orders**

Every deck officer on the vessel was given, on joining, a copy of the "SUN TRANSPORT INC. DECK FLEET POLICY MANUAL, PART A, Revised March 15, 1985," which gives detailed instructions on gas freeing and tank cleaning operations. (See Annex IV).

19. **Qualifications of personnel**

Master - the master is the holder of a Liberian Certificate of Competency as Master of a Foreign-Going Ship issued August 16, 1985. He attended an IMCO Recommended Chemical Course concerning Operational Safety at B.V. CHEMICAL LABARATORY "Dr. A. WEWEY", Rotterdam, March 29 to April 2, 1982. He had flown from Italy, rejoined the vessel, and had taken over command at 1000 on the previous day.

Chief officer - the Chief officer is the holder of an Italian Certificate of Competency as Master of a Foreign-Going Ship (Capitano do Longo Corso) issued December 9, 1978. His Certificate of Competency as Master of a Liberian Ship issued November 2, 1981 had expired November 1, 1986. An application for renewal of the Liberian Certificate was made November 15, 1986 but it had not been received at the time of the accident.

In addition, he was issued a Liberian TANKERMAN (LIQUID CHEMICAL) PERSON-IN-CHARGE qualification No. 0024241 February 28, 1986, and a Liberian TANKERMAN PETROLEUM/CRUDE OIL WASHING (IN CHARGE) qualification No. 0032176 June 25, 1986. He went to sea in 1968 and had been an officer on the "CHIPPEWA" and "NORDIC SUN" since 1981.

Second officer - the second officer is the holder of a Liberian Certificate of Competency as Second Mate of a Foreign Going Ship issued May 2, 1986 and a Liberian TANKERMAN PETROLEUM/CRUDE OIL WASHING (IN CHARGE) issued at New York June 19, 1986. His sea-going career started in 1976, and he has sailed as third mate on the "CHIPPEWA" and "NORDIC SUN" since March 1982. He flew from Italy and rejoined the "CHIPPEWA" on November 13, 1986.

Boatswain - the boatswain has been at sea for 28 years and a boatswain for 15. He has 12 years experience on tankers and

joined the "CHIPPEWA" when built, in 1981. He rejoined the "CHIPPEWA" August 29, 1986 after two months vacation and duty on the "NORDIC SUN" and has a Liberian TANKERMAN (LIQUID CHEMICAL) ASSISTANT qualification No. 0024246 issued February 28, 1986.

Vincenzo Terlizzi - the deceased, had a Liberian TANKERMAN (LIQUID CHEMICAL) ASSISTANT qualification No. 0024265 issued February 28, 1986 in New York. His Seaman's Book was issued December 7, 1961 and he served on a number of Italian vessels; he joined the "NORDIC SUN" October 13, 1983. Subsequently, he served on "CHIPPEWA" and "NORDIC SUN" until the accident.

Findings

On December 16, 1987, while loading at the Sun Oil company berth at Sarnia, Ontario, a seaman who had entered a cargo tank to remove wash water was overcome by toluene vapour, and lost consciousness. He was pronounced dead shortly after, on arrival at a local hospital.

It would appear that the following factors contributed to this accident:

- the method of testing the atmosphere of the tank by a single reading of a combustible gas indicator proved to be inadequate on this occasion with tragic results;

- tests should have been made in other places, at least along the route a tank entrant would take;

- a starboard list, away from the entrance to the purge pipe through which fresh air blown into the tank escaped, caused the wash water to cover the drain holes at the base of the longitudinal frames, and prevented air circulation in that area;

- toluene, which had been introduced into the tank for washing purposes, was entrapped on the surface of the water between the longitudinal frames and gave off toxic vapour which remained to form a pocket in that area; and

- in bending down, the seaman entered this pocket and quickly became incapacitated falling unconscious into the liquid.

Other Findings

The crewman's distressed condition was immediately recognized by the man guarding the tank, but there was difficulty removing the unconscious man because of the lack

of immediately accessible suitable equipment.

The 'pocketing' of dangerous gases in tanks is notoriously unpredictable.

The only certain way of working in such an environment is by using a self-contained breathing apparatus.

Testing a tank atmosphere by smell can be hazardous to health.

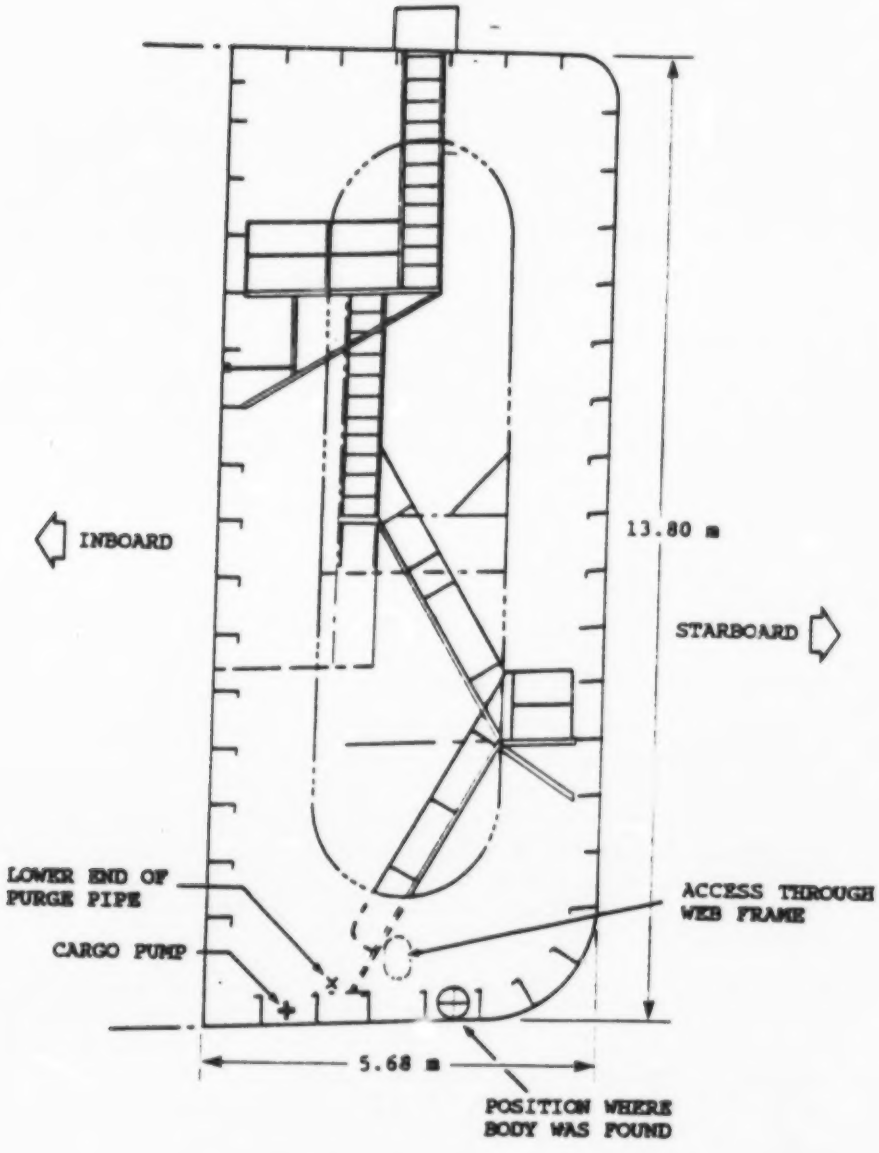
OTTAWA, ONTARIO
SEPTEMBER 1987.

Glossary

flash-point	the temperature at which a vapour will ignite.
Hg	mercury.
IDLH	Immediate danger to life and health
lower explosive limit	minimum concentration of material in air which can be detonated by shock, spark, fire etc.
lower flammability limit	minimum concentration of material in air which will support combustion on contact with source of ignition.
p.p.m.	parts per million.
purge pipe	outlet pipe with opening near bottom of the tank used when 'purging' a tank atmosphere with inert gas or fresh air.
STEL	short term exposure limit - the maximal concentration to which workers can be exposed for a period up to 15 minutes continuously without suffering from 1) irritation, 2) chronic or irreversible tissue change, or 3) narcosis of sufficient degree to increase accident proneness, impair self-rescue, or materially reduce work efficiency, provided that no more than four excursions per day are permitted, with at least 60 minutes between exposure periods, and provided that the daily TLV-TWA also is not exceeded.
TLV	threshold limit value - the maximum concentration that a person may be exposed to for eight hours a day, seven days a week for forty years without feeling any ill effects.
TWA	time weighted average concentrations or levels of an agent for a 40 hour work week to which it is believed nearly all workers may be exposed day after day without experiencing adverse effects.

ANNEX I

"CHIPPEWA"
CROSS-SECTION OF No. 3
STARBOARD TANK
FACING FORWARD



ANNEX II

IMO STANDARD FOR TRAINING, CERTIFICATION AND WATCHKEEPING
CHAPTER V

SPECIAL REQUIREMENTS FOR TANKERS
Regulation V/2

Mandatory Minimum Requirements for the Training and Qualifications of Masters, Officers and Ratings of Chemical Tankers

1. Officers and ratings who are to have specific duties, and responsibilities related to those duties, in connection with cargo and cargo equipment on chemical tankers and who have not served on board a chemical tanker as part of the regular complement, before carrying out such duties shall have completed an appropriate shore-based fire-fighting course; and

(a) an appropriate period of supervised shipboard service in order to acquire adequate knowledge of safe operational practices; or

(b) an approved chemical tanker familiarization course which includes basic safety and pollution prevention precautions and procedures, layouts of different types of chemical tankers, types of cargo, their hazards and their handling equipment, general operational sequence and chemical tanker terminology.

2. Masters, chief engineer, officers, chief mates, second engineer officers and, if other than the foregoing, any person with the immediate responsibility for loading, discharging and care in transit or handling of cargo, in addition to the provisions of paragraph 1, shall have:

(a) relevant experience appropriate to their duties on chemical tankers; and

(b) completed a specialized training programme appropriate to their duties including chemical tanker safety, fire safety measures and systems, pollution prevention and control, operational practice and obligations under applicable laws and regulations.

3. Within two years after the entry into force of the Convention for a Party, a seafarer may be considered to have met the requirements of paragraph 2(b) if he has served in a relevant capacity on board chemical tankers for a period of not less than one year within the preceding five years.

Note: Canada has not yet acceded to this convention but it is complied with by the "CHIPPEWA".

ANNEX III

CANADA SHIPPING ACT

Safe Working Practices Regulations

REGULATIONS RESPECTING SAFE WORKING PRACTICES FOR THE PROTECTION OF PERSONS EMPLOYED ON SHIPS

Short Title

1. These Regulations may be cited as the *Safe Working Practices Regulations*.

Interpretation

2. In these Regulations,

"qualified person" means,

(*a*) in respect of work that is required by law to be performed by the holder of a licence, certificate or other authority, a person who is the holder of such licence, certificate or other authority, and

(*b*) in respect of work that is not required by law to be performed by the holder of a licence, certificate or other authority, a person who, in the opinion of his employer,

Application

3. These Regulations apply to and in respect of the employment of persons in any working area associated with any ship in Canada or on any Canadian ship outside Canada.

General

4. Every employer shall

(*a*) arrange that work in a working area is carried out in a manner that does not endanger the safety or health of any person employed in the work or in connection therewith;

(*b*) adopt and carry out reasonable procedures and techniques designed or intended to prevent or reduce the risk of employment injury in the operation or carrying out of the work; and

(*c*) without limiting the generality of paragraphs (*a*) and (*b*), arrange that the safe working practices set out in these Regulations will be complied with.

5. Every owner of any working area, structure, machinery or equipment used in the operation, maintenance or repair of a ship, or in the loading or unloading of a ship, shall ensure that the working area, structure, machinery or equipment is maintained in a safe condition and complies with these Regulations.

6. Every employer or owner shall ensure that a qualified person

(*a*) is in charge in every working area; and

APPENDICE III

LOI SUR LA MARINE MARCHANDE DU CANADA

Règlement sur les mesures de sécurité au travail

RÈGLEMENT CONCERNANT LES MESURES DE SÉCURITÉ AU TRAVAIL POUR PROTÉGER LES PERSONNES EMPLOYÉES À BORD DES NAVIRES

Titre abrégé

1. Le présent règlement peut être cité sous le titre: *Règlement sur les mesures de sécurité au travail.*

Interprétation

2. Dans le présent règlement,

«personne compétente» désigne

a) dans le cas où la loi exige qu'un travail soit exécuté par le titulaire d'un permis, d'un certificat ou d'une autre autorisation, une personne titulaire d'un tel permis, d'un tel certificat ou d'une telle autorisation, et

b) dans le cas où la loi n'exige pas qu'un travail soit exécuté par le titulaire d'un permis, d'un certificat ou d'une autre autorisation, une personne qui, de l'avis de l'employeur, possède les connaissances et l'expérience voulues pour exécuter le travail en toute sécurité et avec compétence; (*qualified person*)

Application

3. Le présent règlement s'applique aux personnes employées dans un lieu de travail qui se rattache à un navire au Canada ou à un navire canadien en dehors du Canada et à l'emploi de ces personnes.

Dispositions générales

4. Tout employeur doit

a) prendre des mesures pour que, dans un lieu de travail, le travail se fasse sans mettre en danger la sécurité ou la santé de toute personne employée à ce travail ou en support avec ce travail;

b) adopter et mettre en pratique des règles et des techniques raisonnables, visant ou destinées à prévenir ou à réduire le risque de lésion professionnelle pendant la conduite ou l'exécution du travail; et

c) sans restreindre la portée des alinéas *a*) et *b*), prendre les moyens pour faire observer les mesures de sécurité au travail que prévoit le présent règlement.

5. Tout propriétaire d'un lieu de travail, d'un ouvrage, de machines ou d'équipement servant à l'exploitation, à l'entretien, à la réparation, au chargement ou au déchargement d'un navire doit s'assurer que le lieu de travail, l'ouvrage, les machines ou l'équipement sont maintenus en bon état et sont conformes au présent règlement.

6. Tout employeur ou propriétaire doit s'assurer qu'une personne compétente

a) assume la responsabilité de chaque lieu de travail; et

(*b*) makes periodic inspections of every working area or structure and every item of machinery or equipment to ascertain that safe working conditions are maintained.

Holds, Tanks and other Compartments

30. (1) No person shall enter a pump room, cofferdam, ballast tank, oil tank or similar compartment unless he is wearing a breathing apparatus.

(2) Subsection (1) does not apply

(*a*) where a compartment referred to in subsection (1) has not contained a substance that vaporizes to produce a hazardous or dangerous gas and the compartment has been ventilated to the satisfaction of a qualified person, or

(*b*) where the compartment has contained a substance that vaporizes to produce a hazardous or dangerous gas and the compartment has been gas freed and has, subsequently, been tested

(i) by a marine chemist, or

(ii) where a marine chemist is not available, by a qualified person, trained in the use of gas testing equipment, who has at least three years experience of which a minimum of 150 working hours has been gained under proper supervision in the testing and inspection of tanks,

and found safe for persons to enter and for the work to be performed therein.

b) fait des inspections périodiques de tout lieu de travail, de tout ouvrage, de toute machine ou de tout équipement pour assurer le maintien de bonnes conditions de sécurité au travail.

Cales, citernes et autres compartiments

30. (1) Il est interdit d'entrer dans une chambre des pompes, un cofferdam, un ballast, une citerne à pétrole ou un compartiment semblable, à moins de porter un appareil respiratoire.

(2) Le paragraphe (1) ne s'applique pas

a) lorsqu'un compartiment dont il est question au paragraphe (1) n'a pas contenu une substance qui, en s'évaporant, produit un gaz nocif ou dangereux et a été ventilé à la satisfaction d'une personne compétente, ni

b) lorsque le compartiment a contenu une substance qui, en s'évaporant, produit un gaz nocif ou dangereux, mais a été dégazé et soumis à une épreuve

(i) par un chimiste de la marine, ou

(ii) dans le cas où il n'y a pas de chimiste de la marine, par une personne compétente, formée à l'utilisation des appareils d'analyse de gaz, possédant au moins trois années d'expérience durant lesquelles elle a passé au moins 150 heures, sous surveillance appropriée, à éprouver et à inspecter des citernes,

et que ledit compartiment a été jugé sans danger pour les personnes qui auraient à y pénétrer et à y exécuter des travaux.

ANNEX IV

SUN TRANSPORT INC. DECK FLEET POLICY MANUAL,
PART A, REVISED MARCH 15, 1985:

503. TANK CLEANING HAZARDS

The Master is to ensure that all personnel are thoroughly familiar with the potential hazards involved in tank cleaning and tank entry. The ignition hazards outlined in Art. P29 apply also to tank cleaning operations.

503.1 See Art.P29.4. for radio transmitting restrictions.

504. GAS TESTING BEFORE TANK ENTRY

The Chief Officer is responsible for testing tank atmospheres for petroleum vapors, oxygen and other gases during tank cleaning operations and before tank entry.

504.1. The Second and Third Officers are to assist in this task at the Chief Officer's direction.

504.2. Before men are permitted to enter tanks without need of breathing apparatus, tests for petroleum vapors, oxygen and other gases are to indicate that tanks are safe for men.

504.3 Tanks or compartments found to be safe at the time of test may not remain safe due to the release of vapors contained in residue and scale. Continued ventilation and periodic testing are essential to ensuring safe working conditions in these tanks and compartments.

ANNEX V

REGULATIONS FOR THE CONTROLS OF POLLUTION BY NOXIOUS LIQUID SUBSTANCES IN BULK

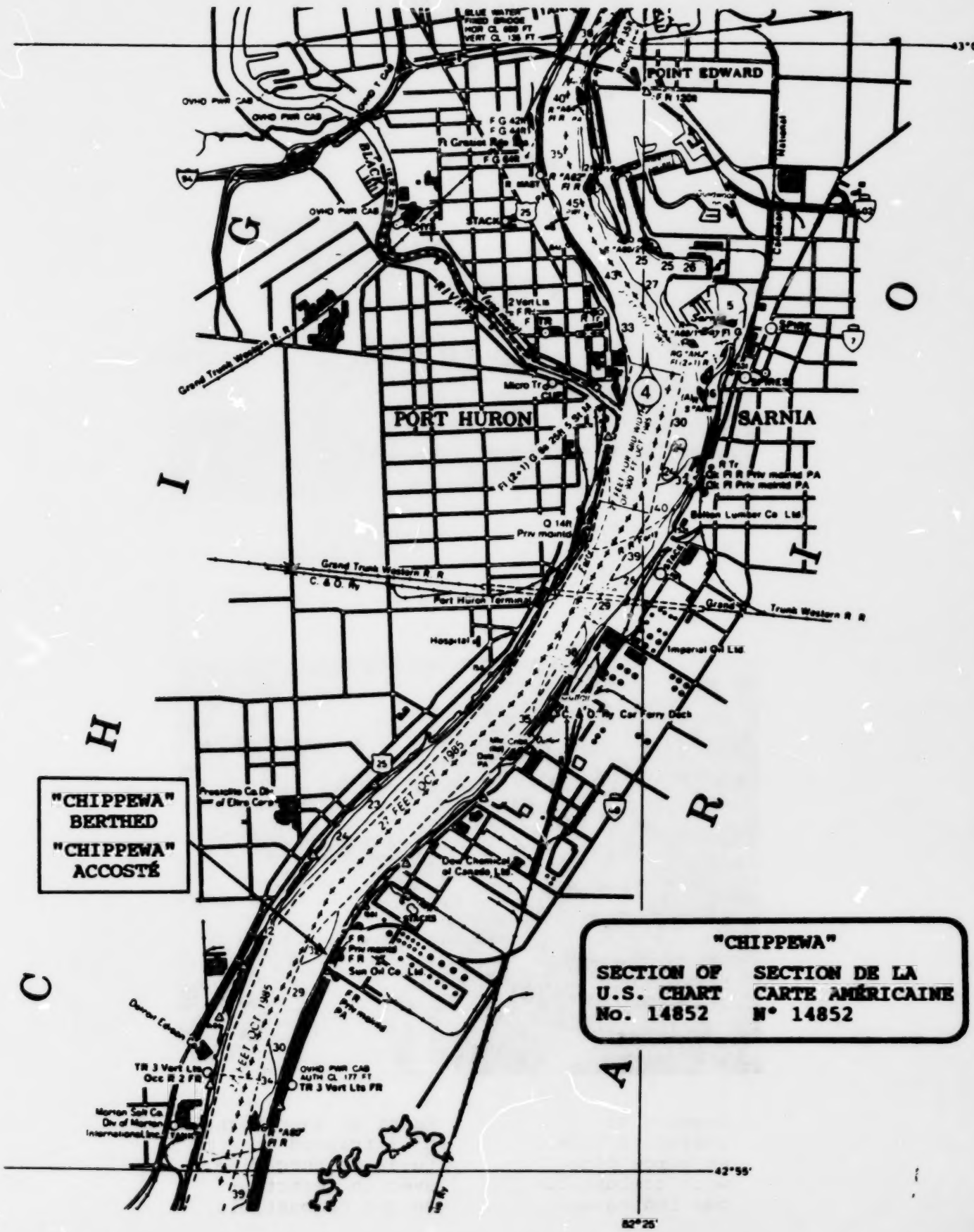
INTERNATIONAL CONVENTION FOR THE PREVENTION OF POLLUTION FROM SHIPS, 1973

Regulation 5A

Pumping, Piping and Unloading Arrangements

(1) Every ship constructed on or after 1 July 1986 shall be provided with pumping and piping arrangements to ensure, through testing under favourable pumping conditions, that each tank designated for the carriage of a Category B substance does not retain a quantity of residue in excess of 0.1 cubic metres in the tank's associated piping and in the immediate vicinity of that tank's suction point.

(2) (a) Subject to the provisions of sub-paragraph (b) of this paragraph, every ship constructed before 1 July 1986 shall be provided with pumping and piping arrangements to ensure, through testing under favourable pumping conditions, that each tank designated for the carriage of a Category B substance does not retain a quantity of residue in excess of 0.3 cubic metres in the tank's associated piping and in the immediate vicinity of that tank's suction point.


POINT EDWARD
PORT HURON
SARNIA
"CHIPPEWA"
BERTHED
"CHIPPEWA"
ACCOSTÉ
"CHIPPEWA"
SECTION OF U.S. CHART No. 14852
SECTION DE LA CARTE AMÉRICAINE N° 14852
43°00'
42°55'
82°25'
Grand Trunk Western R R
Port Huron Terminal
Imperial Oil Ltd
Sun Oil Co Ltd
Dow Chemical of Canada, Ltd
Morton Salt Co
Div of Morton International, Inc
Bluewater Bridge
Black River
Fl Grosse Pte
Micro Trg Q
Hospital
Bidwell Lumber Co Ltd
Ferry Dock
Cut
Range
Light
Buoy
Stack
Tank
Spire
Flagstaff
Chimney
Tr
Occ
Mo
Fl
Q
Vert Lts
Priv marked
Priv maintd
Auth Cl
Dolphin
Pipeline
Cable
Overhead Cable
Ferry Cable
Submarine Cable
Submarine Pipeline
Submerged Pipeline
Submerged Cable
Submerged Ferry Cable
Submerged Overhead Cable

M.V. N.M.
"CHIPPEWA"

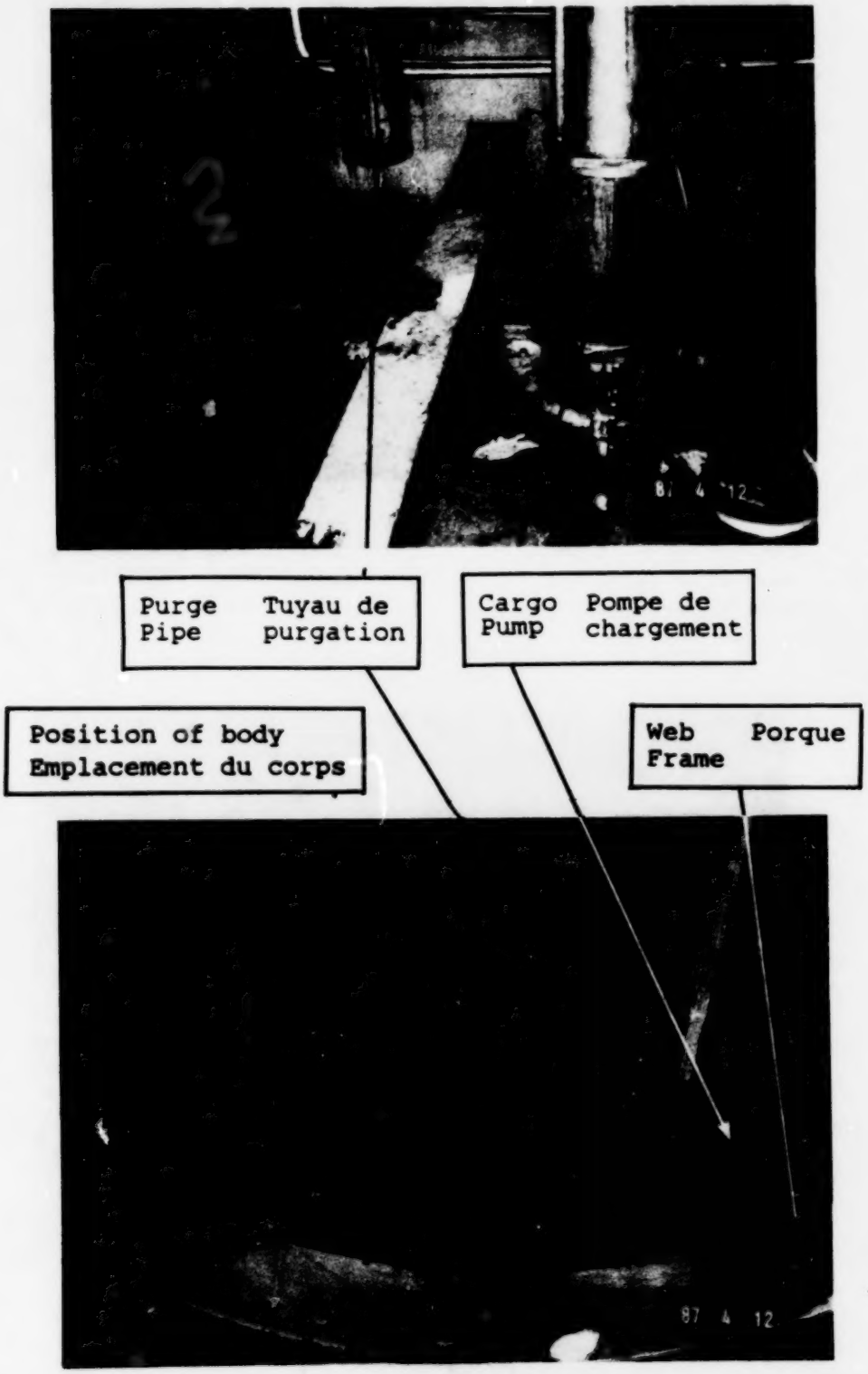
"CHIPPEWA" at Burn's Harbour, Indiana.

"CHIPPEWA" à Burn's Harbour (Indiana).

Testing No. 3 starboard tank at purge pipe with combustible gas indicator.

Essai de la citerne n° 3 tribord au tuyau de purgation avec un détecteur de gaz combustible.

No. 3 Starboard Tank Citerne tribord n° 3



View from ladder in next bay looking aft.

Vue vers l'arrière de l'échelle dans la travée voisine.

Use of air-driven portable pump to remove wash water.

L'emploi d'une pompe à air portative pour éliminer les eaux usées pour le lavage.